

Civil/Structural Lessons Learned on the U.S. EPR™ Project

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Outline



- ▶ Generic Lessons Learned
- ► Seismic Design Challenges
- ▶ Structural Design Challenges
- ► Considerations of COL Applicants
- **▶** Conclusions



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Generic Lessons Learned

- ▶ The use of broad design parameters in the standard design certification potentially yields to excessive concrete and reinforcement requirements for a site
- ► Effective design change controls during the design process are key for success
- Level of analysis / design detail in the certification process must be closely monitored and assessed against the Regulations
- Application submittals must be complete with sufficient level of detail



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Seismic Design Challenges

- Objective for a standard design certification is to provide a design broadly applicable to a range of site characteristics
- Challenging for seismic design because actual site characteristics of importance to C/S design may vary widely from location to location
 - There are a large number of C/S related parameters that must be considered in combination rather than individually in the design
 - Variation in site characteristics generally has less impact to mechanical design since it may be easier to identify enveloping design parameters
- To address this challenge, designers select standard design parameters which bound or cover a broad range of possible inputs. However, the design parameters may be excessively conservative with respect to actual site characteristics
 - Actual site characteristics are inherently unique and are typically less demanding overall when considered in combination



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Seismic Design Challenges (continued)

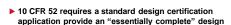
- ➤ To minimize excessive conservatism, more sophisticated modeling techniques were utilized to demonstrate acceptability of the design
 - embedment modeling was to demonstrate stability (accounts for resistance to sliding from lateral soil pressure) and reduce ISRS
 - consideration of high frequency ground motion required a change from use of a stick model to the use of finite element models for seismic analysis
- ▶ Soil Structure Interaction Analyses
 - ♦ DNFSB letter in 2011 related to technical concerns with SASSI
 - Justification of SASSI methods required extensive re-work
 - Complexity of models exceeded current day computing capabilities
 - SASSI was upgraded to take advantage of computer clustering capabilities
 - Supercomputing data centers were used to execute the analyses



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Structural Design Challenges



- Not required or practical to complete all structural design results for a design certification
- Use of "critical sections" is an accepted method to address completeness of the structural design within the standard design certification
- Structural analysis (static and dynamic) is performed and methods and procedures are specified
- Design results are provided only for representative "critical sections" of the structures





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Structural Design Challenges (continued)

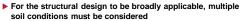
- Guidance for selection of critical sections does not exist generically
- AREVA established a combination of quantitative, and qualitative, and supplementary criteria to select structural elements to perform detailed design
- ▶ Qualitative Criterion
 - SC I structures that perform a safety critical function (e.g. barrier to radioactive releases)
- ▶ Quantitative Criterion
 - Identifies sections that are highly stressed
 - Selected through numerical analysis of finite element analysis results
- ► Supplementary Criterion
 - Uses engineering judgment and obtains adequate representation of typical structural elements



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Structural Design Challenges (continued)



- Design load combinations for containment and other Category I structures are different
 - The permutations of load combinations are numerous
 - Resulting is a large set of computer data to analyze and narrow down to the controlling combinations
 - Structural Design software for Nuclear Codes are not readily available or require significant development
 - With the use of broad parameters the design yields excessive concrete and reinforcement configuration



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Consideration of COL Applicants

- ► Knowledge of actual site characteristics early is beneficial for selecting design parameters
- ▶ Design certifications desire to minimize activities required during implementation by COL applicants
- ▶ Details were included in the U.S. EPR™ design certification to describe methods for reconciling differences between the design parameters and actual site characteristics
 - Difficult to establish a "generic" reconciliation process
 - Reconciliation approach is influenced by the magnitude and nature of the difference (each site is different)
- Other approaches may also be technically acceptable but may result in a "departure" from methods described in the design certification





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Conclusions	

- ► A standardized design that is broadly applicable is an important objective for design certifications
- ▶ There are challenges associated with establishing generic design parameters while avoiding excessive conservatism
- ► Actual site characteristics are inherently unique and may be less demanding when considered overall

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